Estimating the Consequences of a Liquefied Natural Gas Spill

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Estimating the Consequences of a LNG Spill

- Background on important regulations and reports
- Basic considerations
- Spills on water
- Spills on land
- Modeling pool fires
- Modeling vapor dispersion
- Other concerns

Background

- DOT 49 CFR 193 and NFPA 59 A
  - Aimed at land-based facilities only
  - Two exclusion zone requirements defined:
    - Thermal radiation hazard from a pool fire (ignition at release); 5 kW/m^2 (second degree burns in 20 s)
    - Vapor dispersion hazard (ignition at the maximum extent of the flammable cloud); LFL/2 (flammable pockets of gas); DEGADIS and FEM3A
  - Worst Case meteorological conditions: observed or default of 2 m/s (4.5 mph) windspeed; F stability
  - Exclusion zones based solely on consequences

Background

- FERC/ABS report
  - Unconfined LNG spills on water modeled
  - Slightly different approach from 49 CFR 193 for thermal radiation hazards
  - Consistent treatment of vapor dispersion modeling using DEGADIS
  - Impact zones solely based on consequences

Background

- DOE Sandia report
  - Unconfined LNG spills on water modeled differently than FERC/ABS
  - Less sophisticated approach from 49 CFR 193 for thermal radiation hazards
  - Much more sophisticated treatment of vapor dispersion modeling using CFD code VULCAN (not necessarily better)
  - Impact zones based on consequences
  - Risk based on probabilities and consequences

Basic considerations

- LNG vapor is denser than air
- Meteorological conditions
- Spill size (total amount lost); spill rate (how quickly it is lost)
- Hazard endpoints
  - Thermal hazards: 5 kW/m^2 or 1.4 kW/m^2
  - Vapor dispersion hazards: LFL or LFL/2

Spills on water

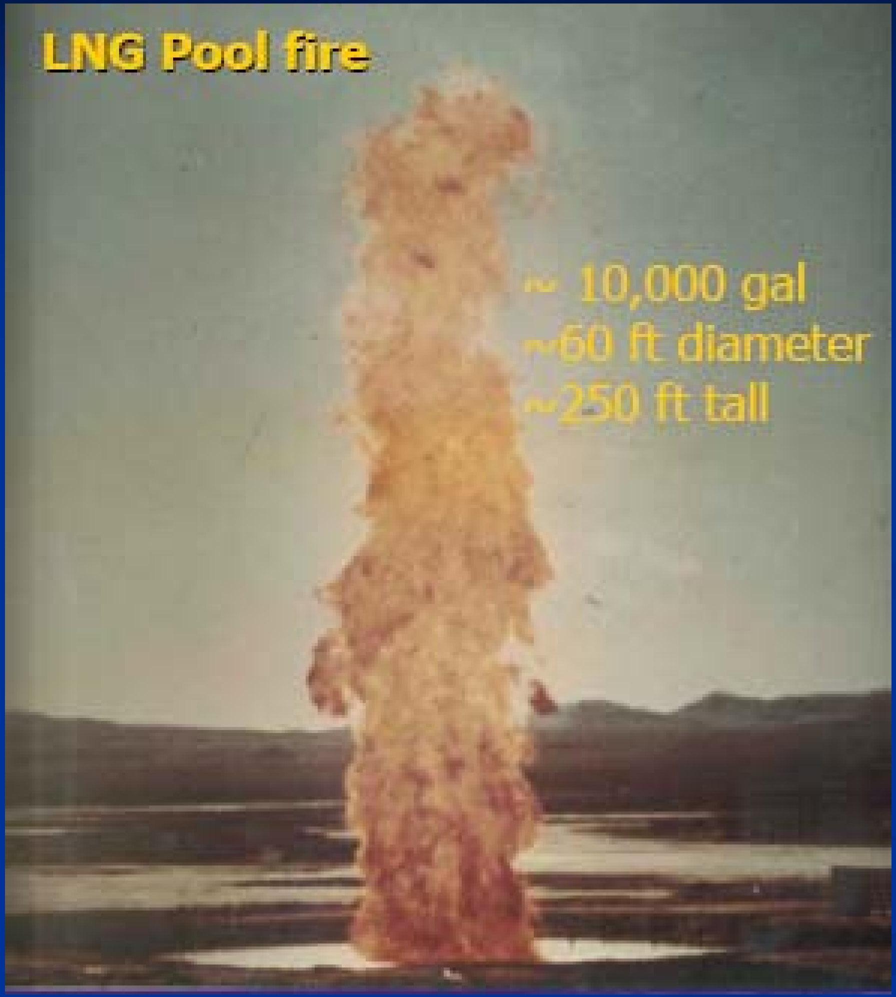
- Liquid spills are unconfined
- Maximum pool size estimate is very important
- Pool size estimate in ABS and Sandia reports
- Burning flux v. boil off flux (without burning)
  - Higher flux means smaller pool
    - Higher flux reduces thermal radiation hazard
    - For vapor dispersion hazard, there are competing effects

Spills on land

- Liquid spills are designed to be confined -- so the very cold liquid can cool the substrate it covers over time
- Typical confinement may temporarily confine the LNG vapor
- As LNG vapor is formed, it mixes with air in the confined space until gas/air overflows the confinement.
- If mixing with air in the confined space is ignored, the gas/air overflow is predicted to occur much later than reality. Such an error can be very significant.
- How much the substrate cools depends on its properties – are they reasonable?

Modeling pool fires

- Surface emissive power
- Atmospheric transmissivity
- Fire height based on its diameter
- View factor is the ratio of the thermal radiation on a target surface to that at the fire surface
- The pool fire diameter importantly effects the fire height and view factor.


LNG Pool fire
~ 10,000 gal
~60 ft diameter
~250 ft tall

Modeling vapor dispersion

- Denser than air effects and turbulence modeling
- Substrate-to-cloud heat transfer
- Verification of the validity of the models for the pertinent physical phenomenon
- Validation of the models and their numerical solution against relevant field-scale and laboratory-scale data


No wind

Other concerns in Sandia's report

- Compromise of insulation system in the event of a large fire
- Embrittlement of materials not designed for cold temperatures which will occur in the event of loss of containment